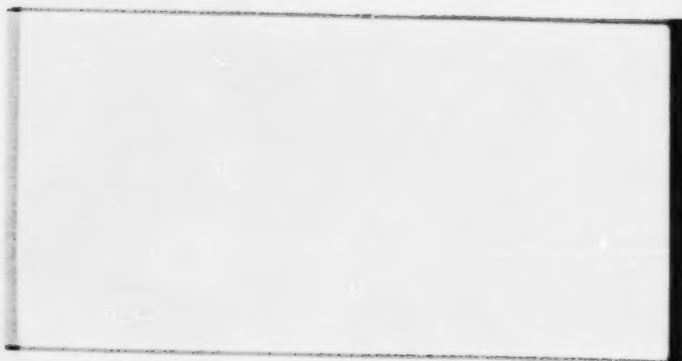
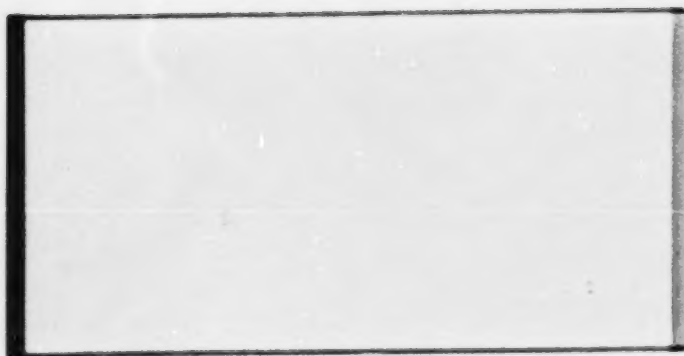




ontario hydro
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ontario hydro research division

ICHTHYOPLANKTON ENTRAINMENT AT THUNDER BAY TGS, 1982

Report No 83-73-K

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ABSTRACT

Rainbow smelt larvae comprised 66% of the total number of larval fish collected in intake-forebay samples at Thunder Bay TGS in 1982. Also collected were burbot (26%) and longnose suckers (8%), while four other species accounted for less than 1% of the total catch. An estimated 24 million smelt larvae in various stages of development were entrained in the CCW system of Thunder Bay TGS between April and August. Assessment of the entrainment impact on rainbow smelt revealed that the number of entrained smelt (expressed as number of adult females) was equivalent to 6% of the Canadian commercial catch for smelt.

job	file	date	report no.
740634-106-592	837.321	March 16, 1983	83-73-K



ontario hydro research division

To Mr. D.K.A. Gillies
Manager
Thermal Generation Division

ICHTHYOPLANKTON ENTRAINMENT AT THUNDER BAY TGS, 1982

INTRODUCTION

At the request of Central Thermal Services, a study was undertaken to determine the significance of ichthyoplankton entrainment at Thunder Bay GS. Species composition, abundance, annual variation and size of fish larvae entrained were investigated. The information obtained together with data from previous studies (BEAK - 1977, 78, 79) provided the basis for determining species which may be adversely affected by station operation.

METHODS AND MATERIALS

Description of the Study Site

Thunder Bay Generating Station is located on Mission Island where the Mission branch of the Kaministiquia River discharges into Thunder Bay. The cooling-water intake is located in the Mission River about 500 m upstream from the station outfall (Figure 1). The intake consists of a surface channel which opens into the Mission River along the steep bank of the dredged ship channel. The outfall, located near the mouth of the Mission River, discharges water to a relatively shallow area of the bay.

The existing generating station has recently been expanded to 400 MW from a 100 MW capacity. The expanded facility acquired two new 150 MW units. The once-through cooling system was modified by deepening the shoreline intake and adding a northward groin extension of the discharge channel. At full capacity, the cooling water flow is $21.6 \text{ m}^3/\text{s}$.

Collection of Samples

Samples were collected from a railway footbridge which crosses the intake-forebay at a point approximately 108 m from the river (Figure 1). Two conical nets were set into the current at a

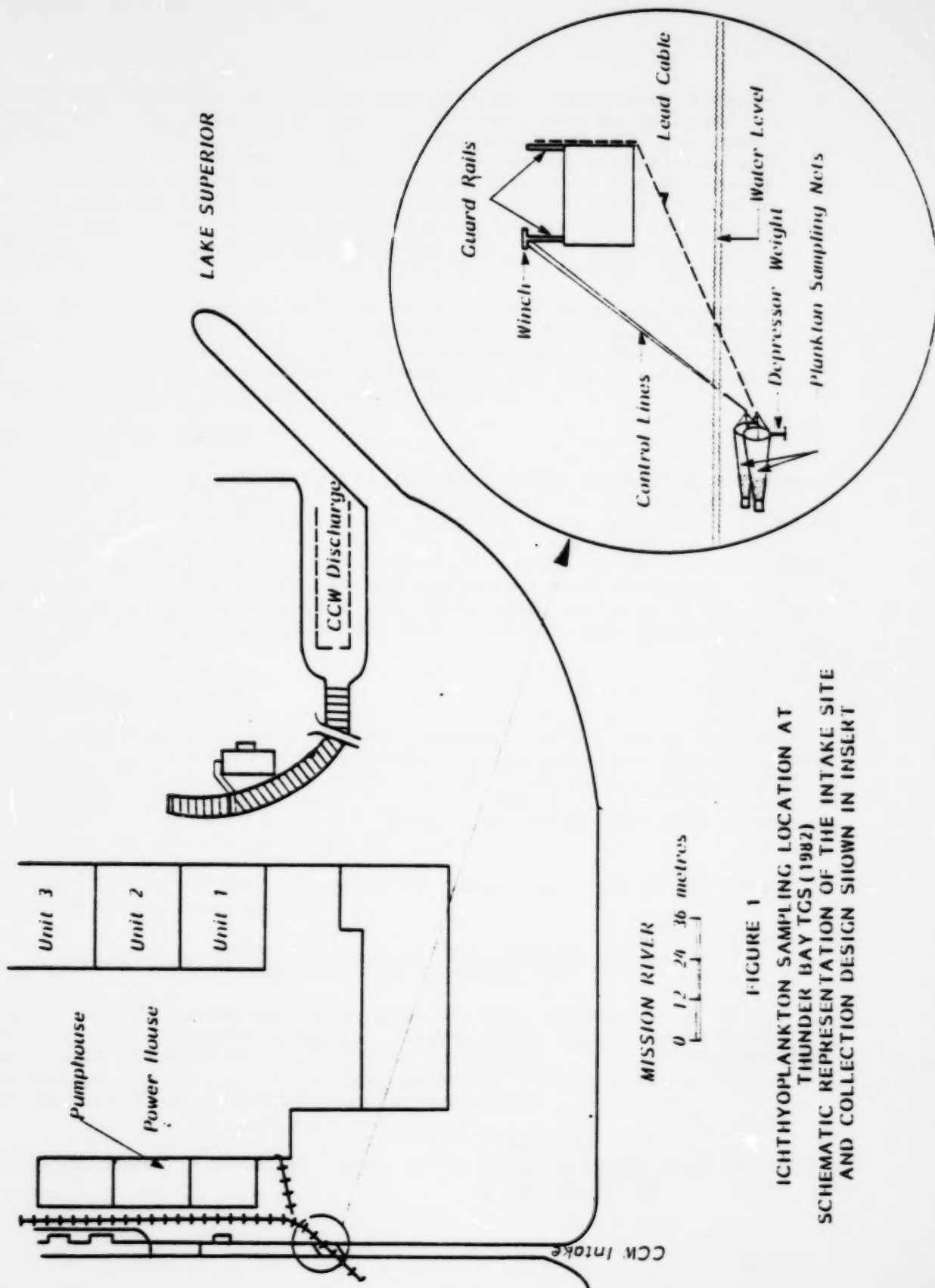


FIGURE 1
 ICHTHYOPLANKTON SAMPLING LOCATION AT
 THUNDER BAY TGS (1982)
 SCHEMATIC REPRESENTATION OF THE INTAKE SITE
 AND COLLECTION DESIGN SHOWN IN INSERT

depth of approximately 0.5 m, and were retrieved with a hand operated winch (Figure 1 inset). The nets had an open-end diameter of 0.5 m, length to diameter ratio of 3:1, and mesh size of 363 μ m. General Oceanics' flow meters placed centrally in the mouth of the nets were used to determine the volume of water sampled during five minute sets. Immediately following collection, samples were rinsed into 1 L jars containing formaldehyde (5% V/v). Duplicate samples were taken 3 and 8 hours after sunrise during the period April 14 to August 16, 1982.

Originally the samples were to be collected from the discharge area to assess any physical damage induced by passage through the cooling system. The construction design of the discharge system prevented any effective sampling and the intake forebay was utilized as an alternative (Figure 1).

Processing of Samples

Following sorting, fish larvae and eggs were identified and enumerated. Total length for each species was recorded from 30 randomly chosen individuals. In samples where less than 30 individuals of any species were present total length was recorded from all representatives. In addition, stage of development and physical condition of all larvae collected were recorded. Specimens were placed into vials containing Davidson's 'B' solution and then into storage jars containing methyl alcohol for future reference.

Presentation of Data

Fish larvae were categorized as: rainbow smelt (*Osmerus mordax*); burbot (*Lota lota*); longnose sucker (*Catostomus catostomus*); carp (*Cyprinus carpio*); yellow perch (*Perca flavescens*); nine-spined stickleback (*Pungitius pungitius*) and rock bass (*Ambloplites rupestris*). Fish eggs were not considered in any analysis since only one egg was caught (May 17, 1982).

Larval fish densities expressed as number per 1000 m³ of water were calculated as follows:

$$\text{Density} = \frac{\text{number of fish larvae caught}}{\text{volume of water filtered (m}^3\text{)}} \times 1000$$

Daily density estimates were based on the average catch in the morning and afternoon samples. These daily density estimates were used to calculate the number of larvae entrained through the condenser cooling water system, assuming larvae passing the collection site were subsequently entrained.

$$\text{Daily Entrainment} = \text{number of larvae} \cdot \text{m}^{-3} \times \left[\frac{\text{condenser cooling water flow (m} \cdot \text{s}^{-1}\text{)}}{\text{}} \right] \times 86\,400 \text{ (sec)}$$

Condenser cooling water volumes at Thunder Bay were determined on a daily basis (Appendix I) by assuming a flow rate of $6.3 \text{ m}^3 \cdot \text{s}^{-1}$ for the operation of two CCW pumps and $3.9 \text{ m}^3 \cdot \text{s}^{-1}$ for one pump operation in Unit 1. For Units 2 and 3 flow rates of $7.6 \text{ m}^3 \cdot \text{s}^{-1}$ and $4.4 \text{ m}^3 \cdot \text{s}^{-1}$ were assumed for two pump and one pump operation respectively. Friday water usage values were applied to Saturday's and Monday values to Sunday's to obtain daily entrainment estimates for weekends. Annual entrainment values were derived by summing daily entrainment figures during the period April 14 to August 16, 1982. Actual volume of water samples during this period represented less than 0.008% of the total cooling water flow.

Assessment of Potential Importance of Entrainment

As outlined in Ontario Hydro Research Division Report 81-211-K, estimates for egg hatching success, mean number of eggs per female and for the natural mortality of larvae from the time of hatch to time of entrainment were used to approximate the equivalent number of adult females giving rise to the larvae and eggs entrained. Assessment of entrainment impact will be determined by comparing the estimated number of mature females which gave rise to the number of larvae entrained to the number of mature females caught by Canadian commercial fishermen.

RESULTS AND DISCUSSION

Species Composition of Collected Ichthyoplankton

The larval fish collected in the Thunder Bay intake-forebay consisted of 7 distinguishable taxa within 7 taxonomic families. The densities and per cent composition of larval caught in the forebay channel are presented in Table 1. Rainbow smelt dominated numerically, representing 65.7% of the catch. The predominance of smelt at Thunder Bay GS was also observed by Beak (1980). Burbot represented 25.7% of the catch and longnose sucker 7.9%, while all other species accounted for 0.7% of the total catch.

Fish larvae were first collected during the third week of April (Figure 2). Larval densities for the entire sampling period were highest (44%) during the last two weeks of May averaging 1000 larvae per 1000 m^3 . The lowest densities of larvae were entrained during July.

(i) Rainbow Smelt

Larval smelt were first collected in mid-May and averaged more than 160 larvae per 1000 m^3 for the entire sampling period (Table 1). Smelt larvae generally dominated the catches from

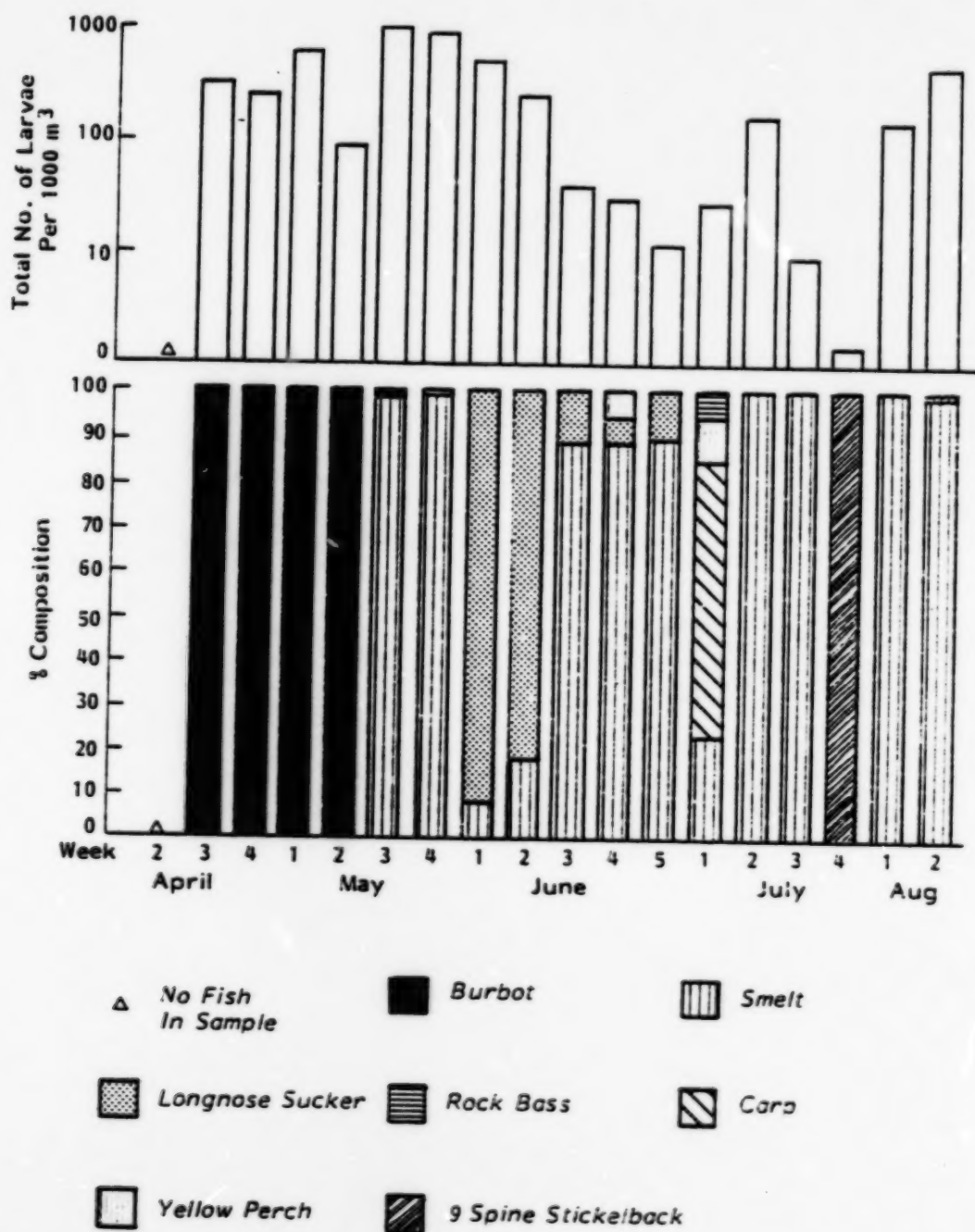


FIGURE 2
SPECIES COMPOSITION AND SEASONAL ABUNDANCE OF
LARVAL FISH ENTRAINED AT THUNDER BAY G.S. 1982

TABLE 1

SUMMARY OF ICHTHYOPLANKTON ENTRAINMENT AT THUNDER BAY GS
FROM APRIL 14 TO AUGUST 16, 1982 (No./1000 m³)

	April	May	June	July	August	Total No Caught	Per Cent Composition	Mean Density (No./1000 m ³)
Smelt		849	31	73	418	1371	65.7	160.9
Burbot	330	202				532	25.7	74.5
Longnose Sucker		62	103			165	7.9	40.3
Carp				5	1	6	0.29	1.0
Yellow Perch		2	1	2		5	0.25	0.4
Nine-Spined Stickleback				1	1	2	0.11	0.1
Rock Bass				1		1	0.05	<0.1
TOTAL	330	1115	135	82	420	2082	100.0	277.3

mid-May to the end of the sampling period. There was a notable difference in densities of smelt larvae taken in morning and afternoon collections with the morning catch representing 34% of the total. In similar studies, however, night collections accounted for 72% of the total smelt catch in day and night samples (Sutherland 1980; Teleki 1976; Ontario Hydro Research Division Report 81-227-K). Daily density estimates in the present study may have been underestimated since no night sampling was conducted.

There was a minimal increase in the total length of entrained smelt larvae between May and July. Smelt larvae generally tripled in length during the month of August (Figure 3). Based on the length of larvae collected, hatching and emergence of smelt occurred during the last two weeks of May and possibly into the first week of June (Figure 3).

(ii) Burbot

Larval burbot was the first to appear and dominated the intake-forebay samples until mid-May. All burbot larvae were early post-hatch fish with a mean total length of 4.7 mm (range 4.0 to 6.0 mm). Burbot larvae made up 25.7% of the total catch with a mean density of more than 74 larvae per 1000 m³ for the entire sampling period (Table 1).

(iii) Longnose Sucker

Longnose sucker was the third most abundant species representing 7.9% of the total catch (>40 ind/1000 m³). This species dominated samples during the first half of June (Figure 2). Mean length of the larvae was 14.7 mm (range 12-21 mm).

(iv) Carp

Carp larvae were only collected during the first week of July. Carp densities averaged 1.0 larvae per 1000 m³ of water for the entire sampling period accounting for <1.0% of the total collected.

(v) Others

Other species collected in the intake-forebay samples included yellow perch (5 individuals), nine-spined stickleback (2 individuals) and a rock bass which together comprised 0.4% of the total catch. Individuals in this category were caught from late June until late July.

Estimated Number of Entrained Ichthyoplankton

Estimates of mean daily entrainment (averaged weekly) and total

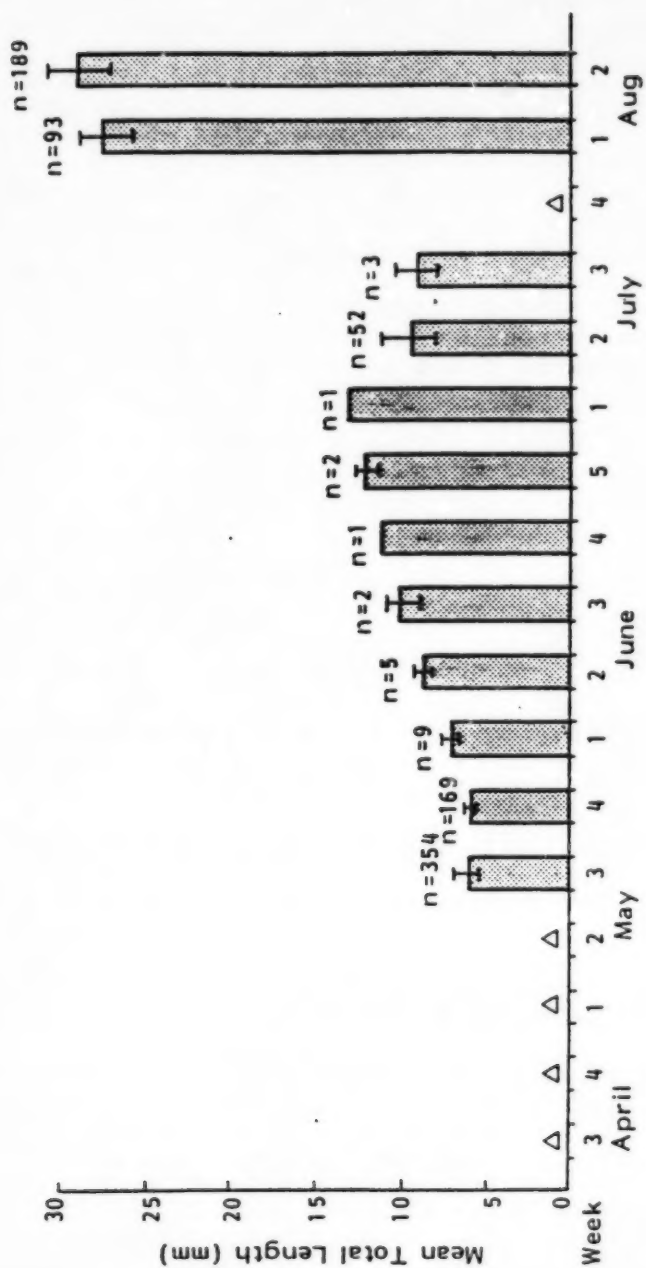


FIGURE 3
MEAN TOTAL LENGTHS (± 1 S.D.) OF LARVAL SMELT CAUGHT
IN INTAKE FOREBAY SAMPLES AT THUNDER BAY G.S. IN 1982

annual entrainment of fish larvae in the condenser cooling system of Thunder Bay GS are presented in Table 2. Over the 18-week study period approximately 24 million smelt larvae were entrained. During the third and fourth week of May alone, it was estimated that over one million individuals per day (69% of total smelt entrainment) passed through the station. These were early post-hatch larvae averaging 5.9 mm in length.

The number of smelt larvae entrained over a 24-hour period on May 25, 1982 was estimated to be 2.5 million. This was the highest daily entrainment of smelt larvae during the 18-week study. Smelt entrainment during June and July was generally less than 50 000 larvae per day but averaged over 500 000 fish per day during August. The annual entrainment value for smelt is probably underestimated since no further sampling occurred past the second week of August.

An estimated 8.9 million burbot larvae were entrained at Thunder Bay from mid-April to mid-May 1982. The highest daily entrainment occurred on May 3, 1982 when 0.8 million burbot larvae were entrained.

The estimated number of longnose sucker larvae entrained in 1982 (June) was 3.6 million fish. Peak entrainment occurred in the first week of June with over 365 000 fish passing through the station each day (Table 2).

The estimated entrainment of the remaining four species (carp, yellow perch, nine-spined stickleback and rock bass) accounted for 0.8% of the total annual entrainment of all species.

Assessment of Entrainment Impact

The 1982 entrainment data were used to assess the potential impact of ichthyoplankton entrainment at Thunder Bay GS. The approach taken was similar to the procedure used to assess ichthyoplankton entrainment at Pickering GS and Nanticoke GS (Ontario Hydro Research Division Reports 81-211-K and 82-55-K respectively).

An estimated 24 million smelt larvae in various developmental stages were entrained at Thunder Bay GS during 1982. In order to back-calculate these data to an equivalent number of adult females, the following assumptions were made: (1) completion of hatch had occurred during the first week of June; (2) all smelt larvae up to this time were considered to be newly hatched (age 0) after which aging occurred by weekly increments; (3) annual natural mortality was assumed to be 92.2% (4.79% weekly) (Ontario Hydro Research Division Report 81-221-K). The estimated 24 million smelt larvae entrained therefore were calculated to represent 27 million age "0" smelt entrained at Thunder Bay GS (Table 3).

TABLE 2

ESTIMATED MEAN DAILY ENTRAINMENT (AVERAGED WEEKLY)
AND ANNUAL ENTRAINMENT¹ OF FISH LARVAE AT THUNDER BAY GS, 1982
(x 1000)

	April				May				June					July					August			Estimated Annual Entrainment (x 1000)
	2	3	4		1	2	3	4	1	2	3	4	5	1	2	3	4	1	2			
Week																						
Smelt	0	0	0		0	0	1192.9	1159.4	37.6	35.1	27.4	24.6	15.4	11.0	129.8	16.0	0	194.3	586.6	24 000		
Burbot	0	363.4	312.6	498.0	81.5	10.6	0	0	0	0	0	0	0	0	0	0	0	0	0	8 900		
Longnose Sucker	0	0	0		0	0	0	0	365.6	143.5	0	2.1	1.5	0	0	0	0	0	0	3 600		
Carp	0	0	0		0	0	0	0	0	0	0	0	0	24.8	0	0	0	0	0	174		
Yellow Perch	0	0	0		0	0	0	3.6	0	0	0	0	0	0	0	0	0	0	0	65		
9-Spined Stickle- back	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	1.8	0	1.6	24		
Rock Bass	0	0	0		0	0	0	0	0	0	0	0	0	2.4	0	0	0	0	0	17		
TOTAL	0	363.4	312.6	498.0	81.5	1203.5	1163.0	403.2	178.6	27.4	28.7	16.9	41.8	129.8	16.0	1.8	194.3	588.2		36 800		

¹Annual entrainment based on 18-week period (mid-April to mid-August).

0 No fish in sample.

The estimated number of eggs which may have given rise to these 27 million age "0" larvae, assuming a natural mortality from deposition to hatch of 99% (Ontario Hydro Research Division Report 80-382-K) was 2700 million (Table 4). The estimated number of females which may have deposited these eggs, assuming a reproductive potential per female of 16 200 eggs (Ontario Hydro Research Division Report 80-382-K) was 167 000 (Table 4).

For comparative purposes, the number of female smelt harvested by Canadian fishermen from Lake Superior was 2.8 million (Table 4). The number was arrived at by assuming: (1) that harvest consisted primarily of 2 and 3 year old fish representing an average weight of 30 g; (2) 50% of the harvest were female smelt. These assumptions were based upon information presented by Bailey, 1964 and Ontario Hydro Research Division Report No 80-382-K respectively. It should be noted that the commercial estimates used were for all of Lake Superior and may not accurately reflect populations in the immediate vicinity of the station.

Smelt entrainment at Thunder Bay GS, expressed as the number of estimated females that produced the larvae, was equivalent to approximately six per cent of the average commercial catch (1976-1981). If smelt entrainment at Thunder Bay GS resembled trends observed at Nanticoke GS (Sutherland, 1980) then the number of smelt entrained could be expected to be four times greater at night than during the day and therefore would significantly change the estimate upward.

The model used makes a number of untestable assumptions and assumes the worst case situation because: (1) the above estimate only represents a potential fish loss if one assumes complete mortality during entrainment [an investigation at Pickering NGS suggests mortality of smelt larvae ranged from 0-39% immediately following passage (Ontario Hydro Research Division Report 82-85-K)]; (2) the average value used for the commercial catch assumes a similar fishing effort over the years. One has to conclude that the actual significance of entrainment losses are significantly lower than estimated.

Assessment of the burbot and longnose sucker entrainment was not possible due to the unavailability of the required population statistics (ie estimate of natural mortality). The consequences of their entrainment to their respective populations however, may be insignificant given the reproductive potential of the female burbot (0.05 to 1.36 million eggs) and longnose sucker (60 000

TABLE 3
ESTIMATED EQUIVALENT NUMBER OF AGE "0"
RAINBOW SMELT LARVAE ENTRAINED AT
THUNDER BAY GS, 1982

Date	Number Entrained per Week (Ni)	Age of Larvae		
		Age in Weeks	Larvae Years	Equivalent Number of Age "0" Larvae (No)
May 15-21	8 350 000	0	0	8 350 000
May 22-28	8 115 000	0	0	8 115 000
May 29-4 June	263 000	0	0	263 000
June 5-11	246 000 (5.39)	1	0.0192	257 782
June 12-18	193 000 (5.2)	2	0.0385	174 830
June 19-25	172 000 (5.2)	3	0.0577	183 598
June 26- 2 July	108 000 (5.0)	4	0.0769	120 226
July 3-9	77 000 (4.8)	5	0.0962	80 628
July 10-16	908 000 (5.9)	6	0.1154	1 065 949
July 17-23	112 000 (5.0)	7	0.1346	140 925
July 24-30	0	8	0.1538	0
July 31- Aug 6	1 360 000 (6.1)	9	0.1731	1 957 061
Aug 7-13	4 160 000 (6.6)	10	0.1923	6 499 155
	23 784 280			27 208 154

TABLE 4
ASSESSMENT OF ENTRAINMENT IMPACT ON
RAINBOW SMELT
THUNDER BAY GS, 1981

(A) Estimated Number of Adult Females Representative of Entrained Smelt.

- Assumption - Date of hatch was June 1 (first week of June).
- Assumption - 4.79% of larvae die during each successive week.
- Estimated - Equivalent number of age "0" smelt larvae entrained = 27 000 000¹.
- Assumption - 99% mortality of eggs from deposition to hatch.
- Estimated - Number of eggs representative of entrained smelt = 2 700 000 000 (included entrainment of eggs and larvae).
- Assumption - Fecundity per adult female smelt = 16 200 eggs.
- Estimated - Equivalent number of adult females = 167 000.

(B) Estimated Number of Adult Females Taken by the Canadian Commercial Fishery.

Average Annual Catch (1976-1981)²

Lake Superior = 172 816 kg

- Assumption - All smelt taken in the commercial catch were adults of which 50% were females.
- Assumption - Smelt catch consisted primarily of 2 and 3 year old fish representing an average weight of 30 g.
- Estimated - Number of females caught in Lake Superior = 2 880 000.

¹Appendix IV

²Ontario Ministry of Natural Resources, J. Tilt per. comm.

eggs) (Scott and Crossman, 1973). Even if one assumes a high egg mortality the number of females giving rise to entrained larvae is likely too low, particularly with regards to the burbot.

SUMMARY

- 1) Larval fish, represented by 7 species, were collected from the intake-forebay at Thunder Bay GS. Rainbow smelt comprised 66% of the total ichthyoplankton catch. Also collected were burbot (25.7%), longnose sucker (7.9%) while carp, yellow perch, nine-spined stickleback and rock bass accounted for 0.7% of the total catch.
- 2) Smelt eleutheroembryos (yolk sac present) were entrained primarily during the latter half of May, while larvae in later stages of development were taken up to mid-August. Burbot were entrained following hatch during late April-early May period. Longnose suckers were entrained throughout June while the remaining four species varied from late May to mid-August.
- 3) An estimated 25 million smelt larvae were entrained in 1982 at Thunder Bay GS based on daytime collections. Annual entrainment of burbot, longnose sucker and all others was 8.9, 3.5 and 0.28 million larvae respectively.
- 4) Smelt entrainment at Thunder Bay GS, expressed as the number of estimated females that produced the larvae, was equivalent to approximately six percent of the average commercial catch for Lake Superior.

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APPENDIX I

MEAN DAILY WATER USAGE ($\text{m}^3 \cdot \text{s}^{-1}$) BY THE CONDENSER
COOLING WATER SYSTEM AT THUNDER BAY GS IN 1982

<u>Date</u>	<u>April</u>	<u>May</u>	<u>June</u>	<u>July</u>	<u>August</u>
1		15.5	8.2	16.0	9.2
2		9.6	8.2	16.0	9.7
3		9.6	8.2	16.0	9.7
4		8.2	8.2	16.0	16.0
5		8.2	8.2	16.0	16.0
6		8.2	8.2	16.0	16.0
7		8.2	8.2	16.0	16.0
8		8.2	8.2	16.0	16.0
9		8.2	8.2	16.0	16.0
10		8.2	8.2	16.0	16.0
11		8.2	8.2	12.8	16.0
12		8.2	8.2	12.8	16.0
13		8.2	8.2	12.8	16.0
14	13.7	8.2	8.2	12.8	16.0
15	13.7	8.2	8.2	12.8	16.0
16	13.7	14.4	8.2	8.7	16.0
17	13.7	14.4	8.2	8.7	
18	10.6	14.4	8.2	16.0	
19	10.6	14.4	8.2	16.0	
20	14.2	14.4	8.2	16.0	
21	10.6	12.2	8.2	20.0	
22	15.8	12.2	12.1	20.0	
23	15.8	13.3	16.0	20.0	
24	15.8	14.4	16.0	20.0	
25	13.5	14.4	16.0	20.0	
26	13.5	12.2	16.0	20.0	
27	15.7	11.3	16.0	16.7	
28	9.6	12.2	16.0	16.7	
29	9.6	12.2	16.0	8.7	
30	15.5	8.2	16.0	8.7	
31		8.2		8.7	

APPENDIX IIa

MEAN DENSITIES (No/1000 m³) OF ALL LARVAL FISH
CAUGHT IN INTAKE FOREBAY SAMPLES
AT THUNDER BAY GS IN 1982

<u>Date</u>	<u>April</u>	<u>May</u>	<u>June</u>	<u>July</u>	<u>August</u>
1		142.2	1337.6	8.0	0
2		963.3	96.5	8.0	0
3		963.3	96.1	13.0	0
4		440.2	64.3	18.0	353.7
5		959.1	64.3	18.0	207.5
6		402.2	685.7	0	211.4
7		431.5	685.7	120.2	211.4
8		431.5	109.8	20.6	278.1
9		283.8	57.8	17.1	278.1
10		136.1	148.1	17.1	1796.9
11		136.1	39.0	0	357.0
12		24.3	39.0	0	106.5
13		39.7	41.4	54.1	81.0
14	0	18.9	43.8	252.9	81.0
15	0	18.9	43.8	159.5	8.7
16	0	723.3	20.4	261.4	8.7
17	0	723.3	32.1	261.4	
18	248.1	908.3	44.6	14.7	
19	248.1	860.0	44.6	14.7	
20	248.6	1081.1	52.4	0	
21	465.0	1460.7	52.4	10.7	
22	424.0	1460.7	47.4	0	
23	285.6	1737.6	36.4	13.0	
24	285.6	2014.4	18.9	13.0	
25	483.8	2014.4	0	0	
26	483.8	453.6	0	0	
27	309.4	164.4	16.2	0	
28	252.6	234.2	16.2	8.5	
29	59.5	234.2	16.4	0	
30	142.2	1162.6	8.0	0	
31		1162.6		0	

0 No fish in sample.

APPENDIX IIb

MEAN DENSITIES (No/1000 m³) OF LARVAL SMELT
CAUGHT IN INTAKE FOREBAY SAMPLES
AT THUNDER BAY GS IN 1982

<u>Date</u>	<u>April</u>	<u>May</u>	<u>June</u>	<u>July</u>	<u>August</u>
1		0	26.1	8.0	0
2		0	34.0	8.0	0
3		0	40.0	13.0	0
4		0	64.3	18.0	353.7
5		0	64.3	18.0	207.5
6		0	0	0	211.4
7		0	0	0	211.4
8		0	109.8	0	278.1
9		0	57.8	9.7	278.1
10		0	101.4	9.7	1796.9
11		0	39.0	0	348.8
12		0	39.0	0	106.5
13		0	41.4	54.1	81.0
14	0	0	43.8	252.9	81.0
15	0	0	43.8	159.5	8.7
16	0	702.9	20.4	261.4	8.7
17	0	702.9	0	261.4	
18	0	908.3	44.6	14.7	
19	0	850.9	44.6	14.7	
20	0	1071.5	52.4	0	
21	0	1460.7	52.4	10.7	
22	0	1460.7	40.0	0	
23	0	1737.6	21.5	13.0	
24	0	2014.4	18.9	13.0	
25	0	2014.4	0	0	
26	0	429.2	0	0	
27	0	164.4	16.2	0	
28	0	234.2	16.2	0	
29	0	234.2	8.7	0	
30	0	71.2	8.0	0	
31		71.2		0	

0 No fish in sample.

APPENDIX IIc

MEAN DENSITIES (No/1000 m³) OF LARVAL BURBOT
CAUGHT IN INTAKE FOREBAY SAMPLES
AT THUNDER BAY GS IN 1982

<u>Date</u>	<u>April</u>	<u>May</u>	<u>June</u>	<u>July</u>	<u>August</u>
1		142.2	0	0	0
2		963.3	0	0	0
3		963.3	0	0	0
4		440.2	0	0	0
5		959.1	0	0	0
6		402.2	0	0	0
7		431.5	0	0	0
8		431.5	0	0	0
9		283.8	0	0	0
10		136.1	0	0	0
11		136.1	0	0	0
12		24.3	0	0	0
13		39.7	0	0	0
14	0	18.9	0	0	0
15	0	18.9	0	0	0
16	0	20.4	0	0	0
17	0	20.4	0	0	0
18	248.1	0	0	0	0
19	248.1	9.1	0	0	0
20	248.6	9.6	0	0	0
21	465.0	0	0	0	0
22	424.0	0	0	0	0
23	285.6	0	0	0	0
24	285.6	0	0	0	0
25	483.8	0	0	0	0
26	483.8	0	0	0	0
27	309.4	0	0	0	0
28	252.6	0	0	0	0
29	59.2	0	0	0	0
30	142.2	0	0	0	0
31					

0 No fish in sample.

APPENDIX IIId

MEAN DENSITIES (No/1000 m³) OF LARVAL LONGNOSE
SUCKERS (MAY & JUNE) AND LARVAL CARP (JULY) CAUGHT IN
INTAKE FOREBAY SAMPLES AT THUNDER BAY GS IN 1982

<u>Date</u>	<u>April</u>	<u>May</u>	<u>June</u>	<u>July</u>	<u>August</u>
1		0	1311.5	0	0
2		0	62.5	0	0
3		0	56.1	0	0
4		0	0	0	0
5		0	0	0	0
6		0	685.7	0	0
7		0	685.7	90.0	0
8		0	0	20.6	0
9		0	0	7.4	0
10		0	46.7	7.4	0
11		0	0	0	0
12		0	0	0	0
13		0	0	0	0
14	0	0	0	0	0
15	0	0	0	0	0
16	0	0	0	0	0
17	0	0	0	0	0
18	0	0	32.1	0	
19	0	0	0	0	
20	0	0	0	0	
21	0	0	0	0	
22	0	0	3.8	0	
23	0	0	7.6	0	
24	0	0	0	0	
25	0	0	0	0	
26	0	0	0	0	
27	0	0	0	0	
28	0	0	0	0	
29	0	0	7.7	0	
30	0	1091.4	0	0	
31		1091.4		0	

0 No fish in sample.

APPENDIX IIIa

MEAN TOTAL LENGTH (± 1 S.D.) OF LARVAL SMELT
CAUGHT IN INTAKE FOREBAY SAMPLES
AT THUNDER BAY GS IN 1982

Date	n	$\bar{x}$ Total Length (mm)		
		± 1 S.D.		
May	17	5.6	$\pm$	0.60
	18	6.6	$\pm$	0.79
	19	6.0	$\pm$	0.0
	20	6.0	$\pm$	0.0
	21	6.8	$\pm$	0.38
	25	6.2	$\pm$	0.45
	26	7.0	$\pm$	0.0
	27	6.1	$\pm$	0.79
	28	6.2	$\pm$	0.51
	31	7.0	$\pm$	0.0
June	2	6.5	$\pm$	0.71
	3	6.0	$\pm$	0.0
	4	8.0	$\pm$	0.0
	8	7.5	$\pm$	2.12
	9	9.0	$\pm$	1.41
	11	9.0	$\pm$	0.0
	18	10.5	$\pm$	2.12
	23	11.0	$\pm$	0.0
	28	12.0	$\pm$	1.41
July	5	13.0	$\pm$	0.0
	14	8.1	$\pm$	2.15
	15	9.4	$\pm$	2.41
	16	7.6	$\pm$	2.41
	19	12.0	$\pm$	0.0
	23	8.0	$\pm$	1.41
August	4	28.7	$\pm$	2.60
	5	26.7	$\pm$	4.44
	6	26.7	$\pm$	4.94
	9	28.7	$\pm$	3.23
	10	28.5	$\pm$	3.15
	11	29.0	$\pm$	3.03
	12	29.2	$\pm$	3.47
	13	27.4	$\pm$	3.27

APPENDIX IIIb

MEAN TOTAL LENGTHS (± 1 S.D.) OF LARVAL BURBOT
CAUGHT IN INTAKE FOREBAY SAMPLES
AT THUNDER BAY GS IN 1982

<u>Date</u>		<u>n</u>	<u>$\bar{x}$ Total Length (mm)</u> <u>± 1 S.D.</u>		
April	19	28	4.0	$\pm$	0.0
	20	34	4.0	$\pm$	0.0
	21	53	4.4	$\pm$	0.49
	22	52	4.4	$\pm$	0.50
	23	35	4.5	$\pm$	0.22
	26	65	4.5	$\pm$	0.43
	27	31	4.7	$\pm$	0.48
	28	14	4.7	$\pm$	0.25
	29	3	4.3	$\pm$	0.58
	30	14	5.0	$\pm$	0.0
May	3	55	5.2	$\pm$	0.38
	4	26	4.8	$\pm$	0.56
	5	59	5.0	$\pm$	0.0
	6	21	4.9	$\pm$	0.22
	7	28	5.0	$\pm$	0.0
	11	6	5.0	$\pm$	0.0
	12	1	5.0	$\pm$	0.0
	13	1	5.0	$\pm$	0.0
	14	1	5.0	$\pm$	0.0
	15	2	5.0	$\pm$	0.0

APPENDIX IIIC

MEAN TOTAL LENGTHS (± 1 S.D.) OF LONGNOSE SUCKER LARVAE
CAUGHT IN INTAKE FOREBAY SAMPLES
AT THUNDER BAY GS IN 1982

Date	n	$\bar{x}$ Total Length (mm)		
		± 1 S.D.		
May 31	34	13.7	$\pm$	0.67
June 1	28	14.1	$\pm$	0.77
2	3	13.7	$\pm$	1.20
3	3	13.3	$\pm$	0.57
7	37	15.9	$\pm$	0.46
10	1	17.0		
17	2	16.5	$\pm$	0.71
23	1	17.0		
29	1	21.0		

POOR

QUALITY

ORIGINAL